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DEVELOPMENT OF COMPLIANT ELECTRIC CABLE FOR MINIMUM WIDTH TOWLI--ETC(U)

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TECHNICAL MEMORANDUM

U.S. NAVAL APPLIED SCIENCE LABORATORY
NAVAL BASE
BROOKLYN, NEW YORK 11251

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(1)

(6) Development Of Compliant Electric Cable For Minimum Width Towlines With Continuous Elastic Fairing For Large Variable Depth Sonar Systems.

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Lab. Project 9300-54, Technical Memorandum 2

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(10) Samuel H. Behr (12) 13p.

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PHYSICAL SCIENCES DIVISION

Approved: J.M. McGREEVY
Associate Technical Director

U.S. NAVAL APPLIED SCIENCE LABORATORY
Naval Base
Brooklyn, New York 11251

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ADMINISTRATIVE INFORMATION

Ref: (a) NAVAPLSCIENLAB Program Summary dated 1 May 1965, SF 001-03-20, Task 8366 . (Conf.)
(b) NAVAPLSCIENLAB Project 9300-54, Technical Memorandum 1 of 4 Sept. 1964.
(c) NAVAPLSCIENLAB Project 9400-53, Technical Memorandum 6 of 17 Dec. 1964.
(d) NAVAPLSCIENLAB Ltr 9460:RJF, Lab. Project 9300-54 of 14 May 1965 to NAVUWTRSOUNDLAB.

1. In accordance with the objectives set forth in reference (a), The Naval Applied Science Laboratory is conducting a research program directed to the development of minimum width towlines for large variable depth sonar systems. This memorandum presents an approach to the development of stretchable insulated conductors and preliminary work on cable modules incorporating these conductors.

ACKNOWLEDGMENTS

2. Work was conducted under the general direction of Mr. G.J. Thompson, Head, Electrical Branch. The Bureau of Ships Program Manager is Mr. D. Seganish, Code 1622.

INTRODUCTION

3. A joint feasibility study of variable depth sonar towlines having minimum frontal area was made by this Laboratory and the Underwater Sound Laboratory as reported under reference (b). The general design concept for a minimum width towline is a tandem arrangement of mechanical and electrical cable members in lieu of the present concentric cable in which the steel armor wires surround the sheathed electrical conductor core. The tandem arrangement of cable components requires an electric cable that will elongate when passing over variable depth sonar hoist device sheaves and when stored on the cable drum. Preliminary investigations on prototype compliant electric cables were conducted by this Laboratory and results were reported under reference (c) and (d). At the present state of the art, there are two applicable electric cable designs that will provide compliancy. One is a sinusoidal configuration of insulated ribbon conductors having "slack" cable for elongation and the other is a straight cable in which both the conductor and insulation stretch. This latter design is considered more suitable for the Applied Science Laboratory continuous elastic faired towline under development as described in reference (b).

APPROACH

4. Experimental stretchable insulated conductors were procured to determine the feasibility of designs. The sample material consisted of two general types. One construction, both in AWG #20 and AWG #14 sizes, was an elastomeric core with braided conductor and insulation extruded over all. The second construction in AWG #20 size was similar except that the conductor was applied in the form of a helix over the elastomeric core. A detailed description of these conductors is given in Table 1. These conductors were also used in the fabrication of experimental hand made cable modules with the objective of gaining information to provide technical guidance in concurrent development contacts on compliant cables being negotiated.

RESULTS

5. Results of evaluations on the conductors were as follows:

Electrical Measurements

	AWG #20		AWG #14
	Braided	Served	Braided
Insulation Resistance* - MEG. - 1000 Ft.	7350	10000	4550
Capacitance* - pf/Ft.	101	109	124
Inductance - μH/Ft.	0.13	0.25	0.12
Conductor Resistance- Ohms/1000 Ft. -			
Relaxed (Not Stretched)	29.8	19.20	5.67
Elongated 10%	31.5	19.20	6.20
Elongated 20%	32.3	19.25	6.20
Elongated 30%	32.7	19.25	6.27
Dielectric Breakdown Voltage* - K.V.	9.1	8.7	12.6

*Measurements made after one hour immersion in water at 27°C.

Notes: 1. Insulation resistance measured at 250 volts D.C.
2. Capacitance and inductance measured at 1000 c.p.s.

The change of resistance of the stretchable conductors was determined using the equipment shown in Figure 1. The apparatus consists of a gear motor operating at approximately 60 R.P.M. with two eccentric drive wheels with provision for conductor elongation adjustment, a cycle counter, a recorder with a calibrating resistance decade for continuously monitoring resistance change of the specimens and a milliohmeter for precise resistance measurements. The monitoring instrumentation will detect resistance changes of one milliohm or more. Results of measurements made on this equipment follow:

Maximum Resistance Change

AWG #20 Braided			AWG #20 Served			AWG #14 Braided		
	Milliohms			Milliohms			Milliohms	
Cycles	Relaxed	Stretched	Cycles	Relaxed	Stretched	Cycles	Relaxed	Stretched
6500	-11	-9	5000	+1	+1	17600	-.1	-.1
17300	-13	-11	10000	0	+1	35500	+.2	+.6
27000	-14	-12	17000	+2	+2	41700	+.3	+.9
46000	-14	-11	20500	+2	+2	50000	+.2	+.7
			50000	+2	+2			

Notes:

1. Change of resistance is based on original measurement on unstretched specimen.

2. Results are resistance changes of 10 inch specimen elongated 20 percent.

3. Initial decrease of resistance of braided conductors indicates improvement of contact conductivity between overlapping braid wires after some stretching and relaxing.

4. Dissection and examination of specimens: AWG #20 Braided (after 46,000 cycles) - No defects in core, conductor or insulation.

AWG #20 Served (after 50,000 cycles) - A few broken strands but no defect in core or insulation.

AWG #14 Braided (after 50,000 cycles) - Nine broken strands but no defect in core or insulation.

The force required to elongate the individual conductors was measured with the following results:

Elongation, Percent	Force - Pounds AWG #20 Braided	Force - Pounds AWG #20 Served	AWG #14 Braided
10	0.7	1.1	1.8
20	1.1	1.7	2.8
30	1.5	2.1	3.7

CONCLUSIONS

6. Conclusions, based on results of preliminary investigations, are as follows:

a. Conductors, either braided or served on an elastomeric core with an overall extruded insulation, are a feasible design for fabricating square or rectangular modules having the elongation required for minimum width VDS towlines.

b. The use of stretchable conductors either braided or served will increase cable capacitance 30 to 50 percent. The inductance of the braided AWG #20 conductor is approximately equal to a standard stranded conductor of equal size, as now being used in concentric type armored VDS tow cables; served stretchable conductors increase the inductance by 75 to 100 percent.

RECOMMENDATIONS

7. Although initial investigations reported in this memorandum demonstrate the feasibility of stretchable conductors for VDS towline applications, the increase in capacitance and inductance as reported herein should be given careful consideration by the designers of VDS electronic gear to insure compatibility. Information should be forwarded to this Laboratory concerning the maximum line capacitance and inductance that can be tolerated. Unless otherwise advised, this Laboratory will proceed on the assumption that the values and the variations stated herein can be tolerated.

FUTURE WORK

8. As it is planned to later evaluate an assembly of stretchable conductors in the form of modules within prototype continuous elastic fairings, a fixture capable of vulcanizing a sheath on cable modules up to 30 feet in length was designed and an overall view of a 10-foot section of this equipment is shown in Figure 2. The device consists of an adjustable size rectangular mold cavity heated by a continuous coil electric element and a mold compression bar. Temperature controllers and recording equipment are included. A section of the mold prepared for vulcanizing is photographically shown under Figure 3 and a view of the vulcanized cable module before being removed from the mold is shown in Figure 4. Since preliminary trials indicate that the non-continuous Laboratory method shows promise in producing a true rectangular section sheathed module, various sheath compounds developed at this Laboratory will be evaluated to determine optimum characteristics for towline environment.

9. The stretchable conductors will be packaged in two or more modules of rectangular cross section to fit within a fairing cavity similar to that shown in reference (b). The number of small conductors for each module will be equal to simplify repair and replacement. The common return conductor will consist of one module containing several parallel connected conductors to provide the required circular mil area of copper. Life tests will be conducted on these modules in the equipment shown under Figure 5 after optimum design has been determined for the individual stretchable conductors. This equipment will also permit an evaluation of the relative durability of module sheath compounds.

Table 1
Description and Dimensions of Conductors

Equivalent AWG conductor size	#20	#20	#14
Conductor configuration	Braided	Served	Braided
Silicone rubber core diam. (cond'r removed)	0.072"	0.088"	0.155"
Diam. over conductor	0.082"	0.089"	0.165"
Number of braid carriers	8	-	16
Strands per carrier	7	-	10
Weave	2 over/2 under	-	2 over/2 under
Picks per inch (approx.)	35	-	26
Strand diam. (bare copper)	0.004"	0.005"	0.005"
Number of strands	-	48	-
Lay of strands	-	1/8", L.H.	-
Diameter over insulation (Silicone rubber)	0.134"	0.125"	0.252"

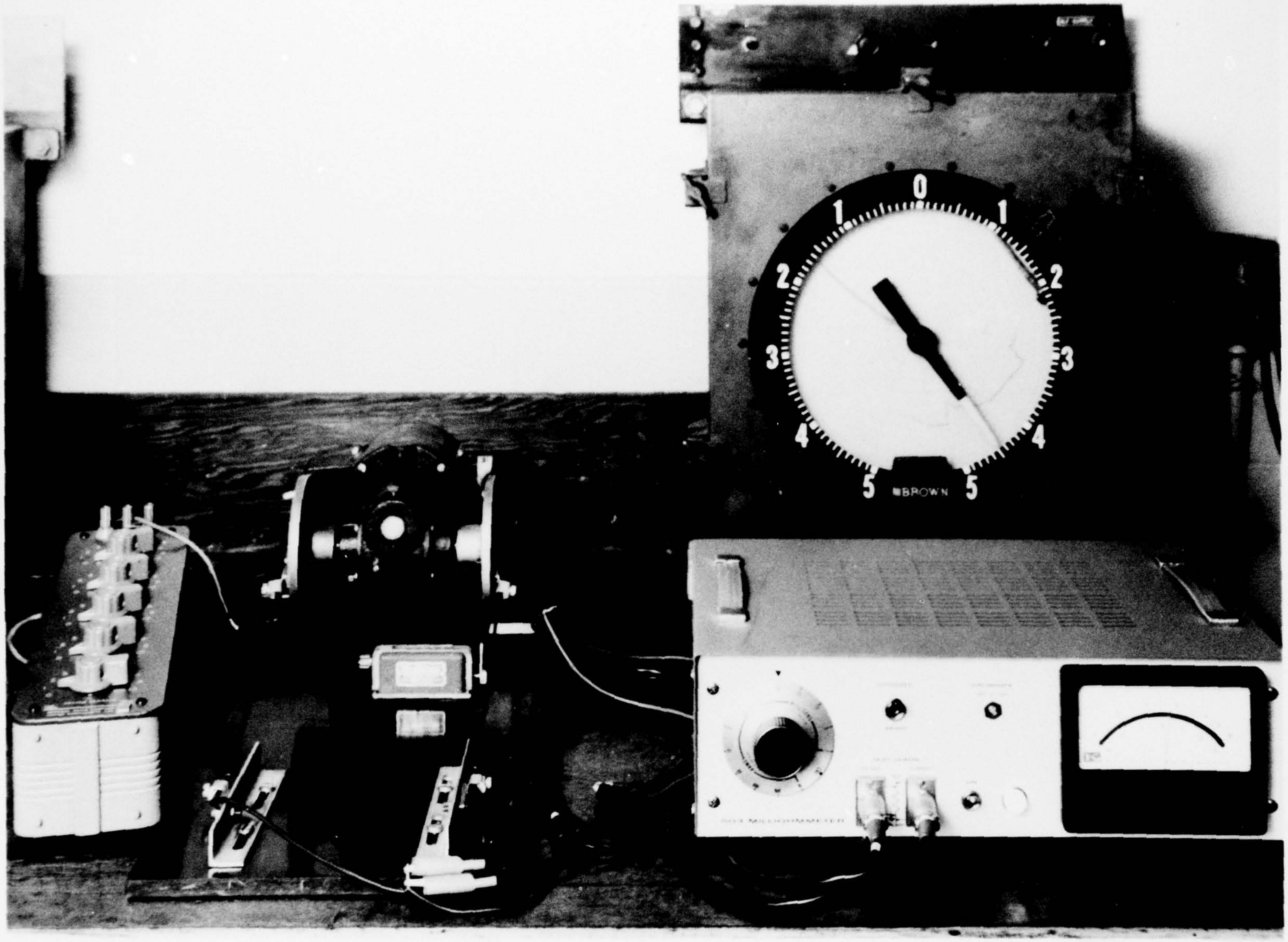

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Figure 1 - Stretchable Conductor Life Test Equipment

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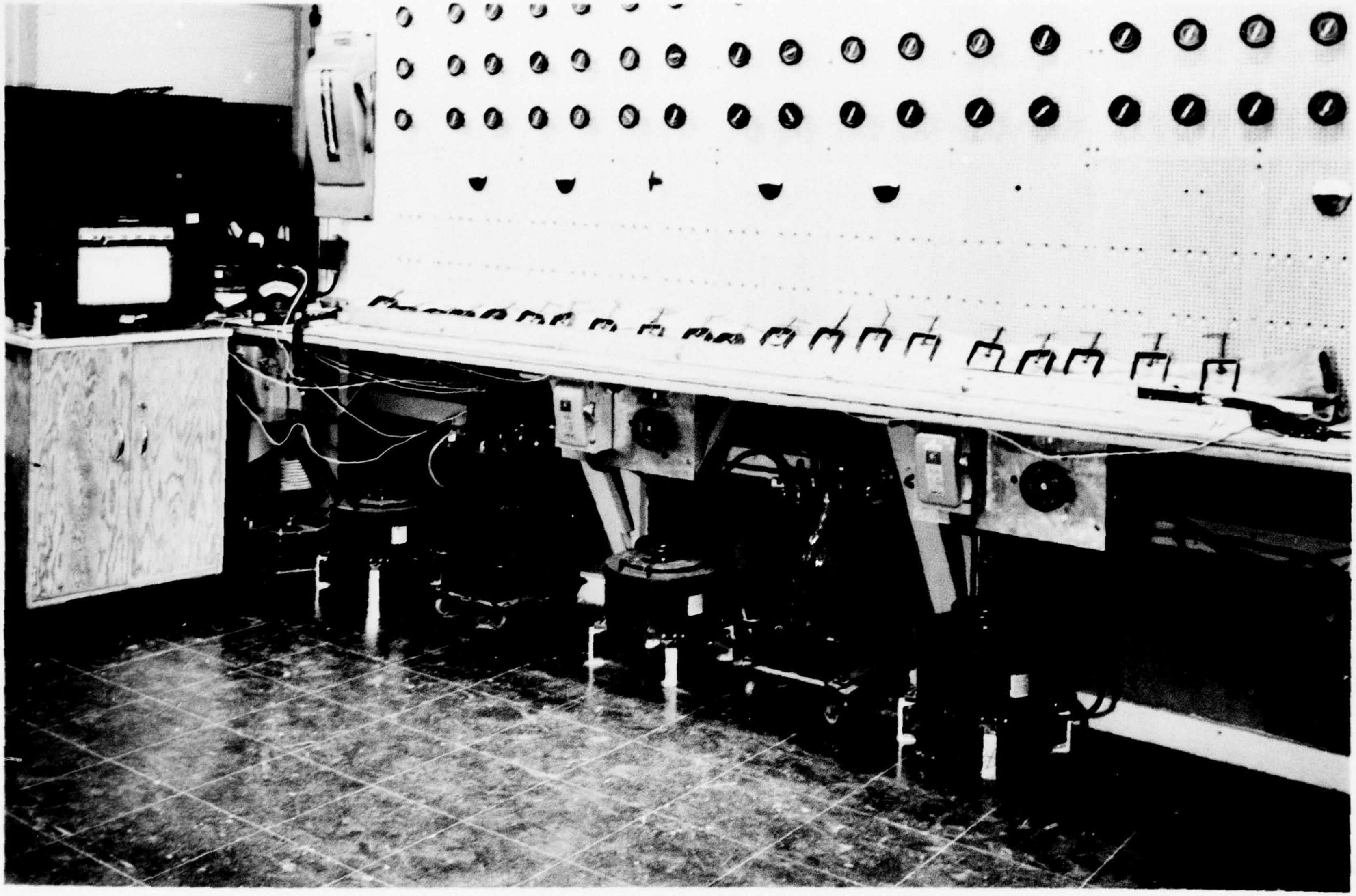

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Figure 2 - Overall View of Vulcanizing Equipment

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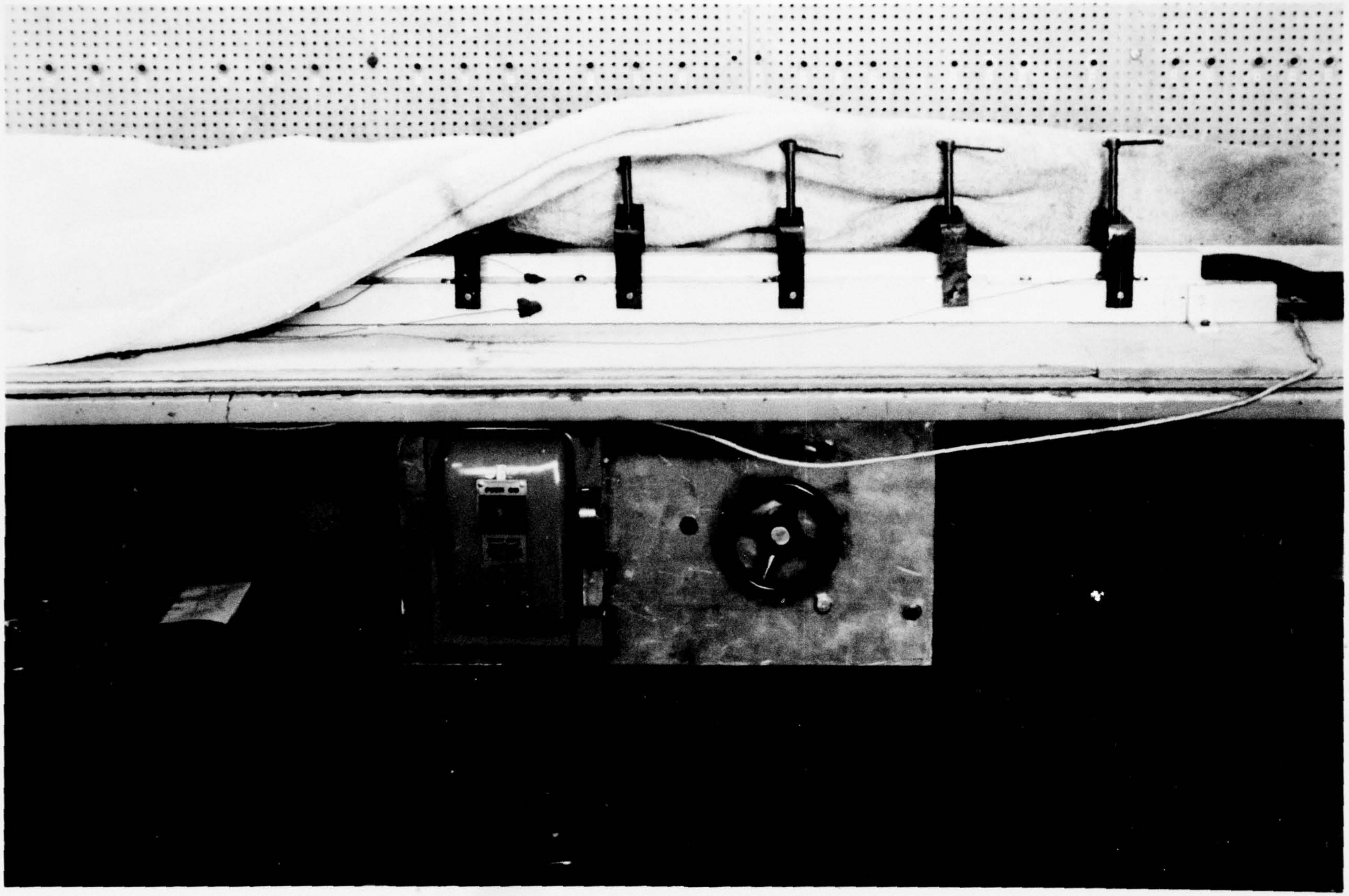

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Figure 3 - Mold Section Prepared For Vulcanizing

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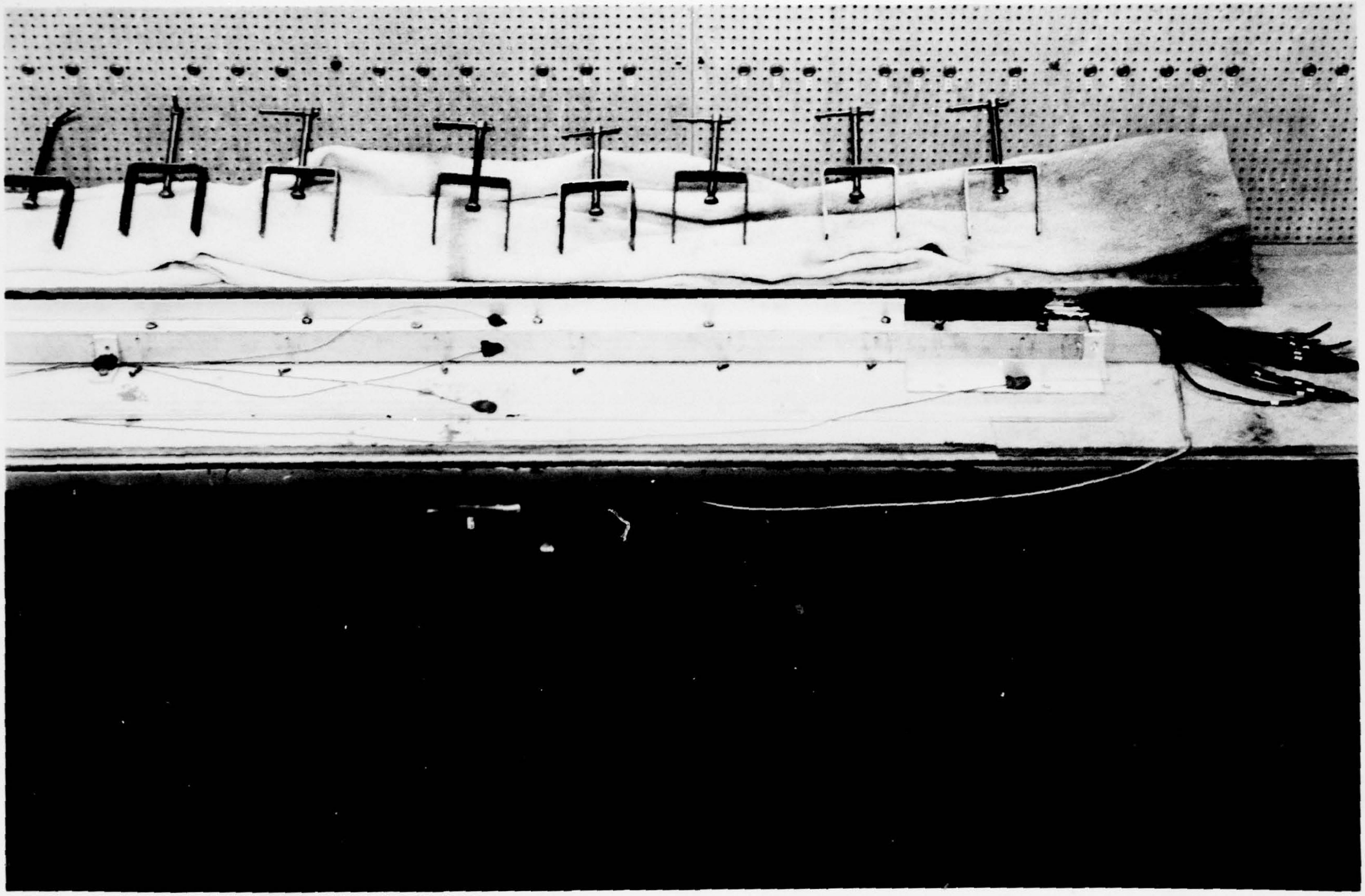

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Figure 4 - Vulcanized Cable Module

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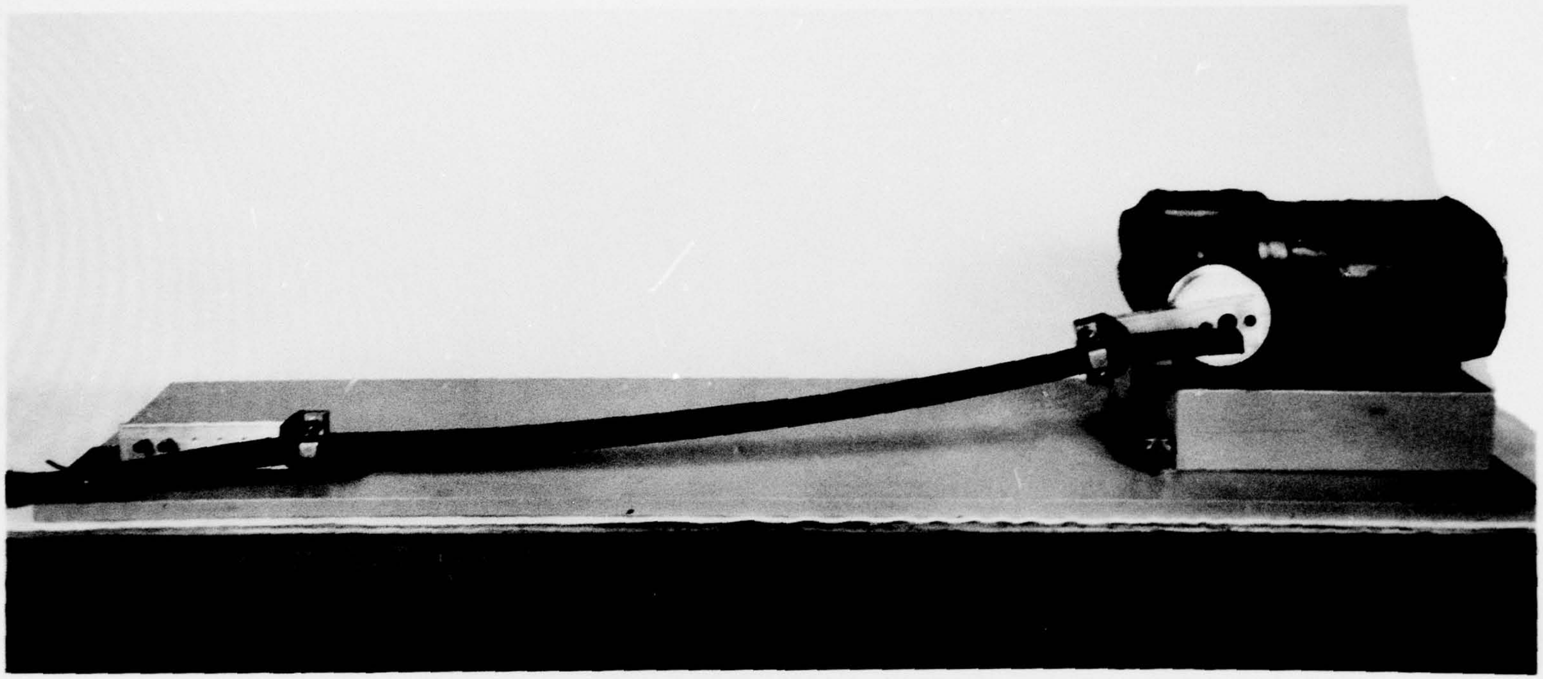

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Figure 5 - Cable Module Life Test Machine

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